

the issue that gave rise to the prior abandonment of complex compound sorption heat pumps, the primary accomplishment of the present development program thus far has been the characterization of many candidate sorption media, leading to large increases in achievable heat- and mass-transfer rates. In particular, two complex compounds (called "CC260-1260" and "CC260-2000") were found to be capable of functioning over the temperature range of interest for the lunar-habitat applica-

tion and to offer heat- and mass-transfer rates and a temperature-lift capability adequate for that application.

Regarding the temperature range: A heat pump based on either of these compounds is capable of providing a 95-K lift from a habitable temperature to a heat-rejection (radiator) temperature when driven by waste heat at an input temperature ≥ 500 K. Regarding the heat- and mass-transfer rates or, more precisely, the power densities made possible by these rates: Power densities ob-

served in tests were 0.3 kilowatt of cooling per kilogram of sorbent and 2 kilowatts of heating per kilogram of sorbent. A prototype 1-kilowatt heat pump based on CC260-2000 has been built and demonstrated to function successfully.

This work was done by Uwe Rockefeller, Lance Kirol, and Kaveh Khalili of Rocky Research for Johnson Space Center. For further information, contact the Johnson Commercial Technology Office at (281) 483-3809. MSC-22952

Improved Refractometer for Measuring Temperatures of Drops

The task of upgrading PDPA hardware for measurement of temperature is simplified.

Marshall Space Flight Center, Alabama

The Dual Rainbow refractometer is an enhanced version of the Rainbow refractometer, which is added to, and extends the capabilities of, a phase Doppler particle analyzer (PDPA). A PDPA utilizes pairs of laser beams to measure individual components of velocity and sizes of drops in a spray. The Rainbow-refractometer addition measures the temperatures of individual drops. The designs of prior versions of the Rainbow refractometer have required substantial modifications of PDPA transmitting optics, plus dedicated lasers as sources of illumination separate from, and in addition to, those needed for PDPA measurements. The enhancement embodied in the Dual Rainbow refractometer eliminates the need for a dedicated laser and confers other advantages as described below.

A dedicated laser is no longer needed

because the Dual Rainbow refractometer utilizes one of the pairs of laser beams already present in a PDPA. Hence, the design of the Dual Rainbow refractometer simplifies the task of upgrading PDPA hardware to enable measurement of temperature. Furthermore, in a PDPA/Dual-Rainbow-refractometer system, a single argon-ion laser with three main wavelengths can be used to measure the temperatures, sizes, and all three components of velocity (in contradistinction to only two components of velocity in a prior PDPA/Rainbow-refractometer system).

In order to enable the Dual Rainbow refractometer to utilize a pair of PDPA laser beams, it was necessary to (1) find a location for the refractometer receiver, such that the combined rainbow patterns of two laser beams amount to a pattern identical to that of a single beam, (2) ad-

just the polarization of the two beams to obtain the strongest rainbow pattern, and (3) find a location for the PDPA receiver to obtain a linear relationship between the measured phase shift and drop size.

This work was done by Amir A. Naqwi of Aerometrics/TSI, Inc. for Marshall Space Flight Center. For further information, contact the Company at (651) 490-3836.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to Aerometrics/TSI, Inc.

*Laser Diagnostic Division
500 Cardigan Road
Shoreview, MN 55126*

Refer to MFS-31531, volume and number of this NASA Tech Briefs issue, and the page number.

Semiconductor Lasers Containing Quantum Wells in Junctions

Additional design degrees of freedom are available for improving performance.

NASA's Jet Propulsion Laboratory, Pasadena, California

In a recent improvement upon $\text{In}_x\text{Ga}_{1-x}\text{As}/\text{InP}$ semiconductor lasers of the bipolar cascade type, quantum wells are added to Esaki tunnel junctions, which are standard parts of such lasers. The energy depths and the geometric locations and thicknesses of the wells are tailored to exploit quantum tunneling such that, as described below, electrical resistances of junctions and concentrations of dopants can be reduced while laser performances can be improved.

$\text{In}_x\text{Ga}_{1-x}\text{As}/\text{InP}$ bipolar cascade lasers have been investigated as sources of near-infrared radiation (specifically, at wavelengths of about 980 and 1,550 nm) for photonic communication systems. The Esaki tunnel junctions in these lasers have been used to connect adjacent cascade stages and to enable transport of charge carriers between them. Typically, large concentrations of both n (electron-donor) and p (electron-ac-

ceptor) dopants have been necessary to impart low electrical resistances to Esaki tunnel junctions. Unfortunately, high doping contributes free-carrier absorption, thereby contributing to optical loss and thereby, further, degrading laser performance.

In accordance with the present innovation, quantum wells are incorporated into the Esaki tunnel junctions so that the effective heights of barriers to quantum tunneling are reduced (see figure).